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Patients' involvement in e-health services quality assessment: A system for the automatic interpretation of SMS-based patients' feedback

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ABSTRACT

Purpose: Effective communication between patients and health services providers is a key aspect for optimizing and maintaining these services. This work describes a system for the automatic evaluation of users' perception of the quality of SmsCup, a reminder system for outpatient visits based on short message service (SMS). The final purpose is the creation of a *closed-loop control system* for the outpatient service, where patients' complaints and comments represent a feedback that can be used for a better implementation of the service itself.

Methods: SmsCup was adopted since about eight years by an Italian healthcare organization, with very good results in reducing the no-show (missing visits) phenomenon. During these years, a number of citizens, even if not required, sent a message back, with comments about the service. The automatic interpretation of the content of those SMS may be useful for monitoring and improving service performances.Yet, due to the complex nature of SMS language, their interpretation represents an ongoing challenge. The proposed system uses conditional random fields as the information extraction method for classifying messages into several semantic categories. The categories refer to appreciation of the service or complaints of various types. Then, the system analyzes the extracted content and provides feedback to the service providers, making them learning and acting on this basis.

Results: At each step, the content of the messages reveals the actual state of the service as well as the efficacy of corrective actions previously undertaken. Our evaluations showed that: (i) the SMS classification system has achieved good overall performance with an average F1-measure and an overall accuracy of about 92%; (ii) the notification of the patients' feedbacks to service providers showed a positive impact on service functioning.

Conclusions: Our study proposed an interactive patient-centered system for continuous monitoring of the service quality. It has demonstrated the feasibility of a tool for the analysis and notification of the patients' feedback on their service experiences, which would support a more regular access to the service.

1. Introduction

Among e-health applications [1,2], those based on short message service (SMS) are emerging as effective methods for health promotion. As a matter of fact, SMS messages are widely available and accessible, allowing for reaching individuals of all socio-economic status. Moreover, they are asynchronous, that is they can be accessed at a time that suits an individual.

Mobile phone applications in healthcare setting cover several clinical areas and focus on improving processes or outcome of care. In this work we focus on the specific problem of patient's non-attendance or no-shows. A no-show is a missed visit, i.e. a visit that has been scheduled but not respected by a patient, without any notice from him. This phenomenon is common in every healthcare organization that delivers services on a scheduling basis, and may have various causes: the most frequent is that patients simply forget the appointment, or cannot attend it due to a sudden disease, or a last minute business, and forget to notify the doctors [3]. No-shows are a serious problem for both healthcare organizations and patients since they reduce the efficiency and quality of care delivery. Every such event causes waste of resources and time: a planned visit, while not executed, still entails a fixed cost that is not reimbursed by the national healthcare system. Equally, clinicians' time, which could have been used to serve other patients, is lost and waiting lists extend. On the other hand, from patients'

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perspective, a no-show might result in reduction of care quality because it can affect the health of patients who may need treatments.

Since forgetfulness is the major cause of no-show, a reminder system should alleviate the problem. In 2005, such a system, called SmsCup, has been implemented at the healthcare organization "Azienda Ospedaliera di Pavia" (from here on "AO-Pavia"), achieving very good results (the no-show rate decreased from 8% to 4.2%) [4,5]. The patient is not required to answer the reminder, but someone does, for different reasons: to thank for the service, to notify a possible error (e.g., he does not remember having booked any visit), to ask for further details, etc. After collecting a significant number of answers, we decided to analyze them, in order to evaluate patients' perception of the service. Moreover, this analysis should help to individuate possible system weaknesses and consequently spur corrective actions. As a matter of fact, any reminder that a patient perceives as an error, reveals an organizational bug or malpractice. The purpose of this study is to exploit patients' responses to reminders for improving the quality of service. The patients' SMSs, in fact, may be used for a double purpose. First, they might point out incorrect behaviors, of both patients and health care professionals, that inhibit the effective use of the service. For instance, elderly patients often give to the organization the mobile number of a relative (such as a son, a grandson, etc.), getting him/her confused when receiving the reminder. Just as, front-office operators sometime do not ask for the mobile number at all or, in front of a first refusal, they do not pursue the patient's consensus, by explaining them the usefulness of the service. Second, analyzing patients' SMSs from time to time, we can measure the effects of system improvements made on the basis of the SMSs themselves (e.g., observing a decreasing number of SMS claiming for errors, indicates a service improvement).

In this work, we present a system, based on natural language processing (NLP) techniques for SMS classification, that supports the healthcare organization in the outpatient service improvement.

2. Background and related work

2.1. Involving patients in service development

A better understanding of patients' preferences, needs and values is becoming an important issue in modern healthcare, especially in view of the increasing attention to patient-centered care [6]. Some studies have examined the effect of several forms of patients' involvement on healthcare service provision (i.e., improved patient-provider electronic communication, range of consultations, patient forums, interviews with service users), across a range of settings [7–10]. They recognized the great potential that such initiatives can have on services improvement, but asserted that it is too early to make strong conclusion about the impact on health outcomes and quality. A more recent literature review [11] explored the impact of ICT on patients' satisfaction. Despite the absence of clear evidence of positive impact, the authors found a widespread awareness of the need of incorporating patients' perspective into the care delivery and suggested the inclusion of patients' satisfaction as a strategic component of quality in medical informatics. Thus, after focusing on communication within and among healthcare organizations [12], over the past decade, ICT has increasingly considered patient-health providers communication, with the aim of making care more patient-centered.

2.2. Mobile devices for healthcare

Interventions involving cell phone found in scientific literature employ both cell phone voice and SMS technologies, and cover a variety of health areas such as diabetes [11], smoking cessation [13], HIV/AIDS [14], asthma [15], hypertension [16], physical activity [17], orthodontics [18], hepatitis vaccinations [19], stress management [20], physical disability [21], dialysis [22] and general outpatient clinics [23,24]. A number of studies have assessed the effectiveness of different systems [4,5,11,13–20]. As a result, they showed how such interventions have brought positive impact in term of health outcomes (e.g., compliance with medication taking and smoking cessation) and care processes (e.g., lower number of failed appointments and quicker diagnosis and treatment). For more details, research on the use of cell phones is well described in some comprehensive reviews by Krishna et al. [25] and by Hasvold et al. [26]. These systems, however, mostly rely on predefined reminders to be sent to patients according to some clinical conditions, but do not consider to receive a feedback from the patient in the form of an SMS text to analyze. Since this is the focus of our work indeed, in the next section we illustrate existing NLP methods for extracting information from SMS.

2.3. Information extraction from SMS text

Information extraction (IE) techniques have become an invaluable resource for searching about a particular topic in electronic archives of scientific literature [27,28], and for enriching the content and the utility of electronic clinical systems [29]. Excellent efforts have been documented in the literature on IE from textual biomedical documents [27–32], and its subsequent application in summarization, case finding, decision-support, or statistical analysis tasks. As well, the automatic analysis of SMS text through NLP techniques could allow for properly accessing and processing the SMS text and thus for deducing its syntactic and semantic structure. However, despite the growing significance of SMS as a means for the delivery of healthcare information, to date little has been published on NLP approach specific to SMS in the domain of medicine. We are aware of only one publication [33] about a system designed for extracting specific information from patients' informal SMS on medication management.

Some works exist about normalization of text message more in general [34–36]. As a matter of fact, the SMS language is far from standard: users are creating a novice language, overlooking orthographic and syntactic rules with a great emphasis on compressions (e.g., ad hoc abbreviation and acronyms due to space restrictions), and written representations of the sounds, such as "r" instead of "are". Another common phenomenon in SMS is represented by emoticons, such as :-(, :-) and ;-). All these aspects contribute to make NLP analysis of SMS an ongoing challenge.

3. Methods

3.1. Functional architecture

Fig. 1 shows the system we developed on top of SmsCup. This system allows for preparing, every working day, an SMS package to be sent to patients. The software retrieves data from the database hosted by the AO-Pavia. Then, SMSjob, a commercial gateway, sends the SMS package. The system sends this simple message three days before the scheduled date: *"The Healthcare Company of Pavia reminds you the visit of dd/mm. If you want to cancel it, call free 800448800. Thank you for the cooperation"*.

As mentioned in the introduction, patients receiving an SMS are not supposed to answer, but someone (about 0.5–1%) does. Considering from 120,000 to 150,000 SMSs sent/year, we receive about 600–750 replies/year. It is difficult to provide a more precise figure because some of the replies are empty or apparently unrelated to the service (due to patients' mistakes).

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